APPENDIX G

EXAMPLES OF NUTRIENT CONCENTRATION RANGES AND RELATED HYDROGRAPHIC DATA FOR SELECTED ESTUARIES AND COASTAL WATERS IN THE CONTIGUOUS STATES OF THE UNITED STATES

Atlantic Coast Systems

BOSTON HARBOR, MA (Source: Kelly 1998)
WAQUOIT BAY, MA (Source: Valiela et al. 1992)
SEEKONK-PROVIDENCE RIVER REGION OF NARRAGANSETT BAY, RI (Source: Doering et al. 1990)
WESTERN LONG ISLAND SOUND AND HUDSON-RARITAN ESTUARY, NY/NJ (Source: O'Shea and Brosnan 2000)
HUDSON RIVER, NY (Source: Lampman et al. 1999)
DELAWARE RIVER ESTUARY (Source: Lebo and Sharp 1993)
MARYLAND COASTAL BAYS (Source: Boynton et al. 1996)
CHESAPEAKE BAY, MD/VA (Source: Magnien et al. 1992)
CHESAPEAKE BAY (Harding and Perry 1997)
YORK RIVER ESTUARY, CHESAPEAKE BAY, VA (Source: Sin et al. 1999)
NEUSE RIVER ESTUARY, NC (Source: Rudek et al. 1991)
CAPE FEAR RIVER ESTUARY, NC (Source: Mallin et al. 1999)
COASTAL GEORGIA (Source: Hopkinson and Wetzel 1982)

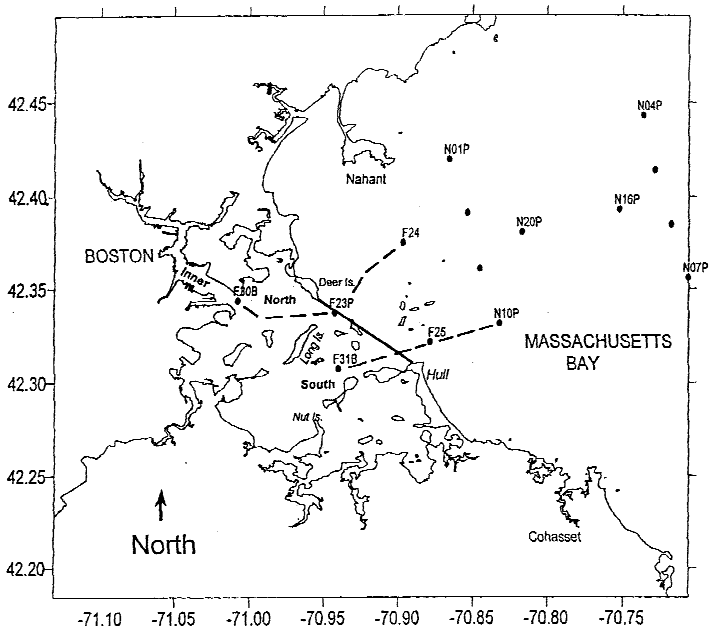
Gulf of Mexico Estuaries

GULF OF MEXICO CASE STUDIES (Source: Bianchi et al. 1999)
GALVESTON BAY, TX (Source: Santschi 1995)

Pacific Coast Systems

EMBAYMENT OF PUGET SOUND, WA (Source: Bernhard and Peele 1997)

Boston Harbor



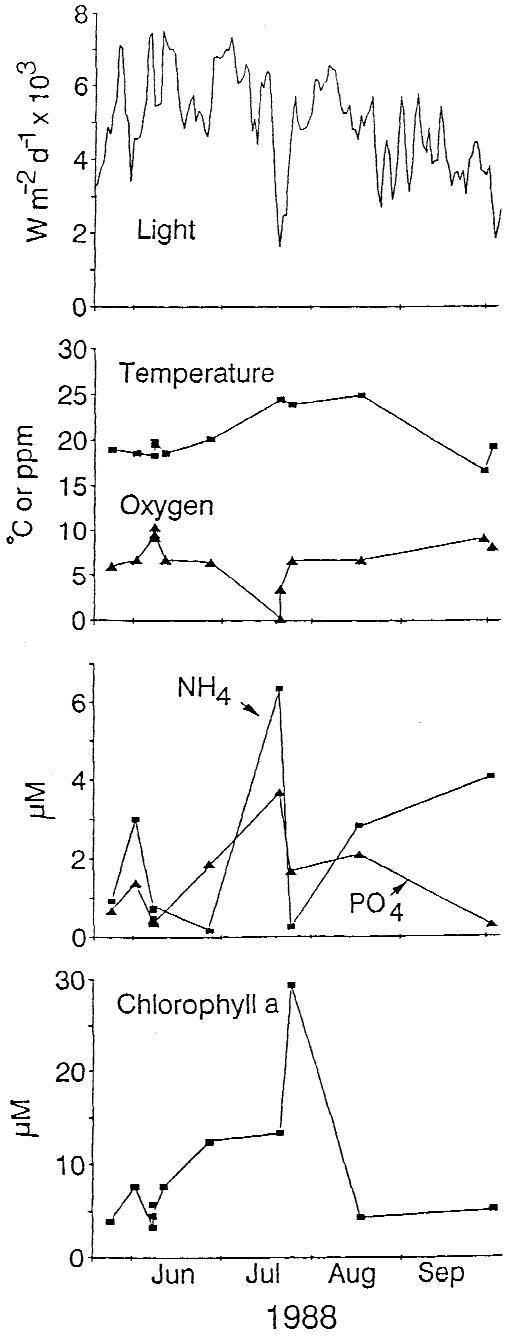
The study area (N latitude and W longitude) in Boston Harbor and western Massachusetts Bay. The boundary between the Harbor and the Bay is defined by the solid line from Deer Island to Hull combined with the dashed lines showing the 2 high-resolution transects, the spatial limits of data for box modeling are depicted. Dots position some watercolumn monitoring stations that were sampled during 1994. Stations prefixed with 'N' surround the future offshore outfall, which is centered between Stns N20P and N16P about 15 km from Deer Island. Data from 2 lines of Bay staions (N01P to N10P and N04P to N07P, each representing about 10 km distance) were used to provide approximate concentrations for the future tidal source region for the Harbor.

Survey	Transect	Bay C_o (to calculate ocean loading)						Harbor C_i (to calculate Harbor output)					
		BA[a] (m^{-1})	NH_4 (µM)	DIN (µM)	TN (µM)	PO_4 (µM)	SiO_4 (µM)	BA[a] (m^{-1})	NH_4 (µM)	DIN (µM)	TN (µM)	PO_4 (µM)	SiO_4 (µM)
W9402	North	2.23	3	10.5	20	0.8	8	2.34	4	14	28.5	0.8	12
	South	1.89	2	9.5	18	0.8	8	1.78	3.5	12.5	19	1	9.5
W9403	North	1.23	1	2	nd	0.3	1	1.61	nd	nd	nd	nd	nd
	South	1.07	0.75	1.75	nd	0.3	0.75	1.32	nd	nd	nd	nd	nd
W9404	North	0.85	2	3	16	0.3	1.5	1.29	3	4.5	25	0.3	3
	South	1.11	1	2	14	0.25	1	1.30	2.5	3.25	18	0.25	1.4
W9405	North	1.53	1.5	3	nd	0.5	2.75	1.84	nd	nd	13	0.5	nd
	South	1.46	1.5	3	nd	0.5	2.75	2.00	nd	nd	11	0.8	nd
W9407	North	1.55	1.5	2	14	0.7	1.5	2.15	2.25	2.6	17.5	0.6	1.5
	South	nd	nd	nd	nd	nd	nd	nd	2	3	14.5	0.8	2.5
W9409	North	2.04	5	6	nd	1	4.5	3.26	2.1	nd	11	0.7	nd
	South	1.50	5	6	nd	1	4.5	1.64	1.4	nd	10.5	0.55	nd
W9411	North	1.51	7	11	21	1.1	6	2.07	10	15	26	1.3	8
	South	1.78	4	7	16	1	5	1.90	11	16	24	1.3	7
W9412	North	2.13	6	8	nd	1	3	2.66	2.25	nd	20	1.5	nd
	South	nd	6	8	nd	1	3	nd	nd	nd	2.1	1.5	nd
W9413	North	1.94	2	3.5	nd	0.5	2.75	2.06	15	20.5	29.7	1.7	nd
	South	1.86	2	3.5	nd	0.5	2.75	2.06	18	20.5	29.7	1.7	nd

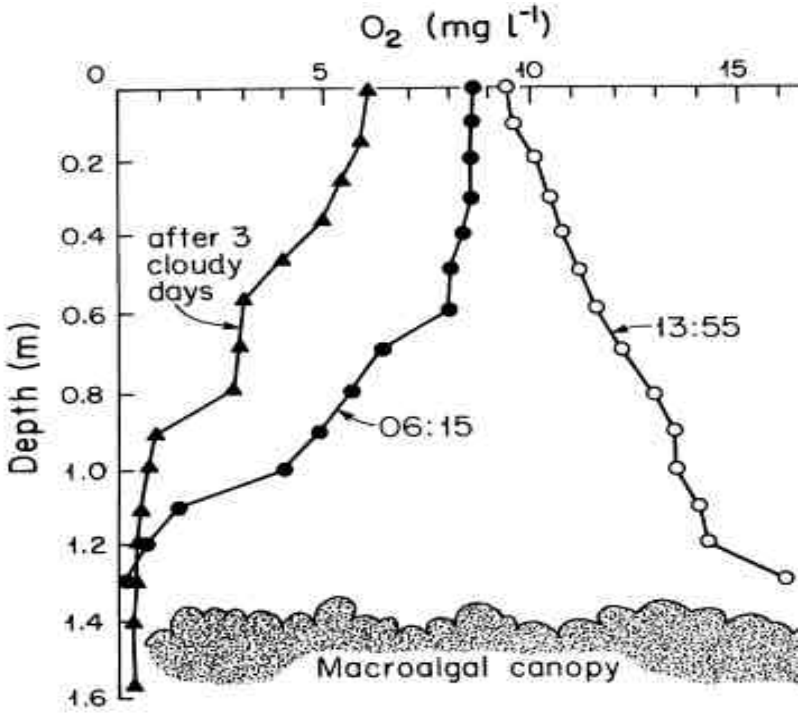
[a]From high-resolution, *in situ* sampling. Converted to TSS as described in the text

Bay (C_0) and Harbor (C_1) concentration data used in calculating Harbor-Bay exchange. BA: beam attenuation from transmissometer readings; nd: not determined.

Waquoit Bay

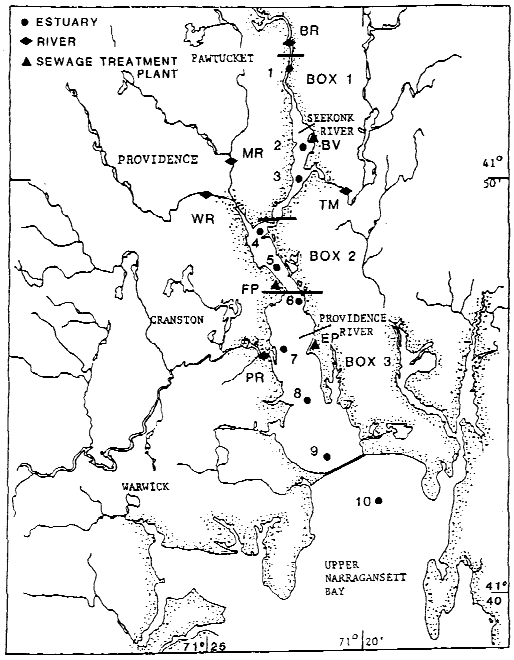


Time course of light, temperature, oxygen, ammonium, phosphate, and chlorophyll in water of Waquoit Bay, summer 1988. Modified from Costa et al. (in press).

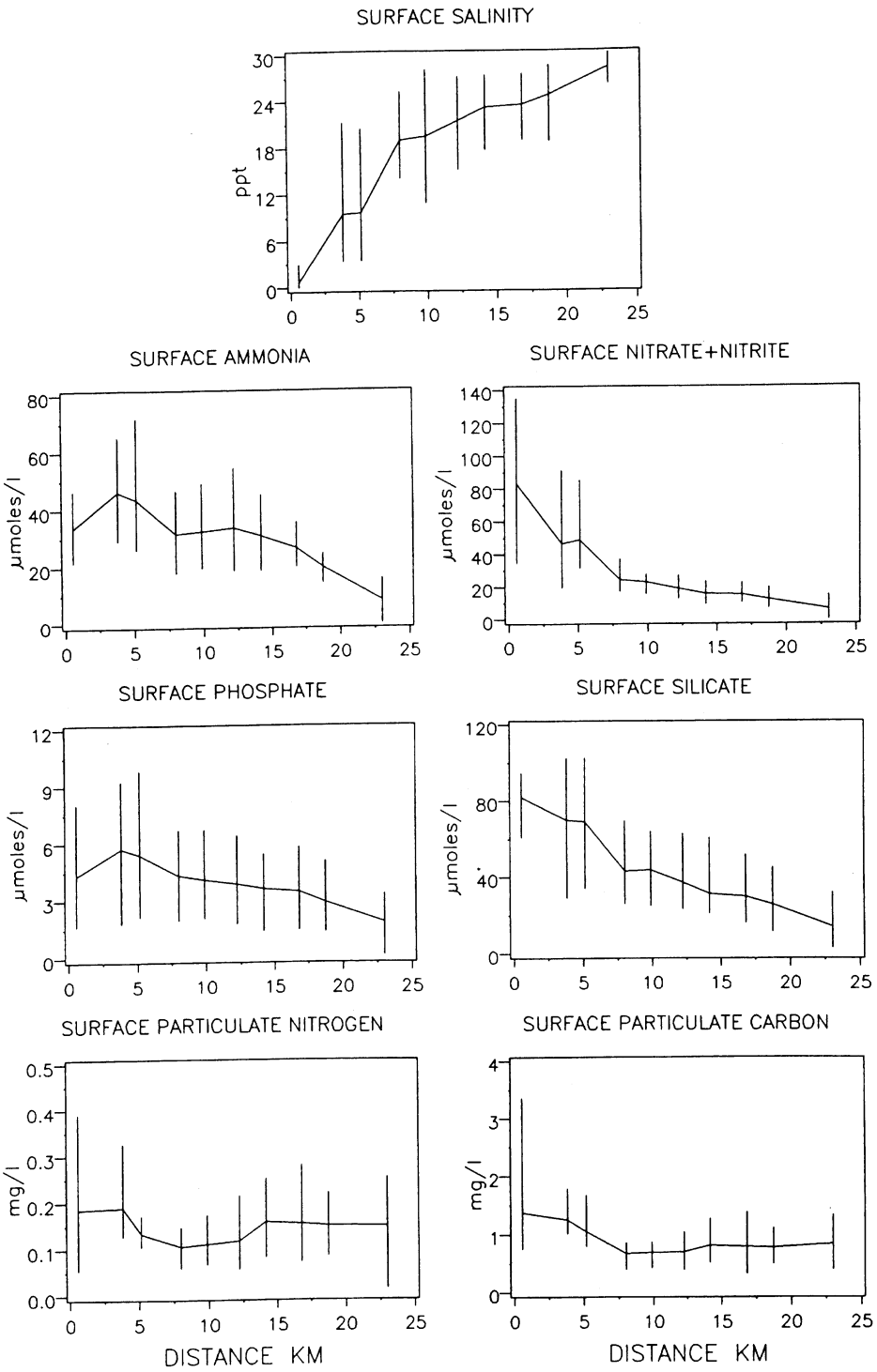


Vertical profiles of oxygen in Childs River during dawn and midafternoon of a sunny day (circles), and during afternoon after three cloudy days in a row. Data from C. D'Avanzo.

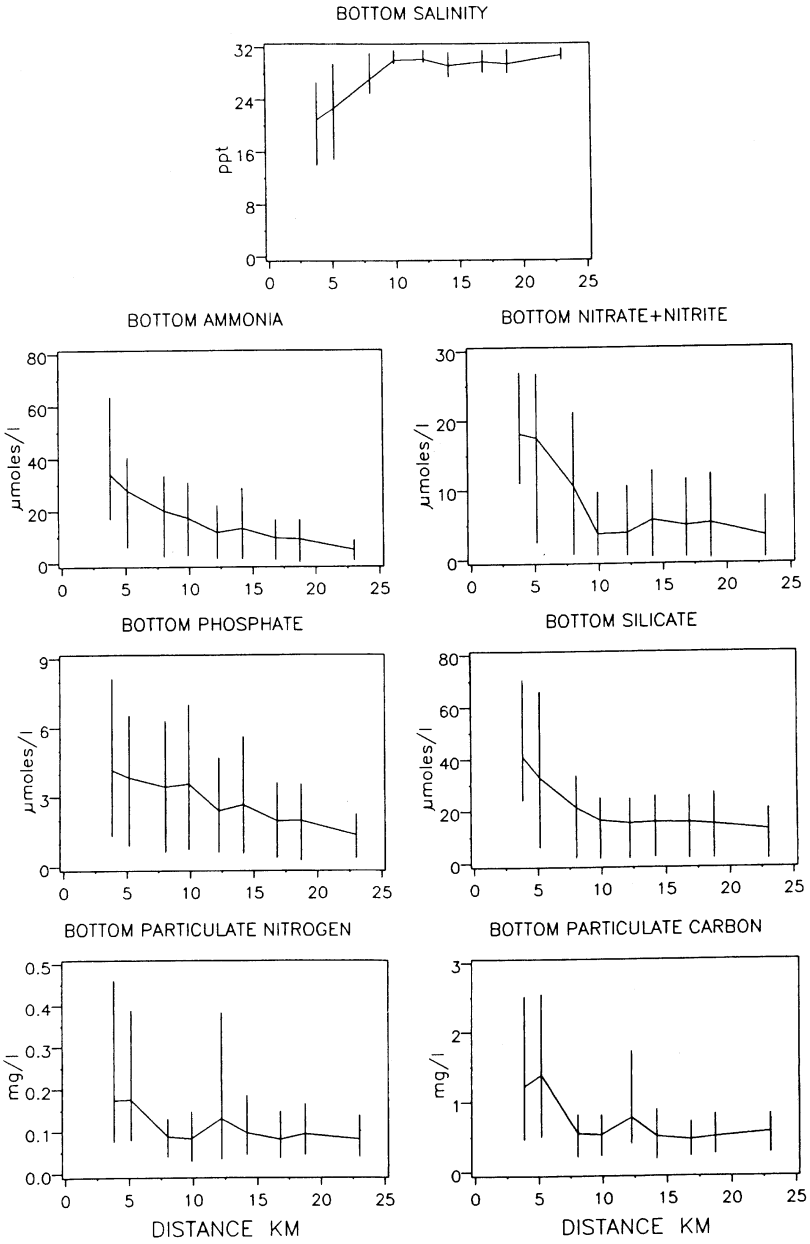
Seekonk—Providence River Region, Narragansett Bay



Station locations, Solid lines delimit boxes used in modeling effort. BR=Blackstone River, BV= Blackstone Valley Sewage Treatment Plant (STP), TM= Ten Mile River, MR Moshassuck River, WR=Woonasquatucket River, FP=Field's Point STP, EP=East Providence STP, PR= Pawtuxet River

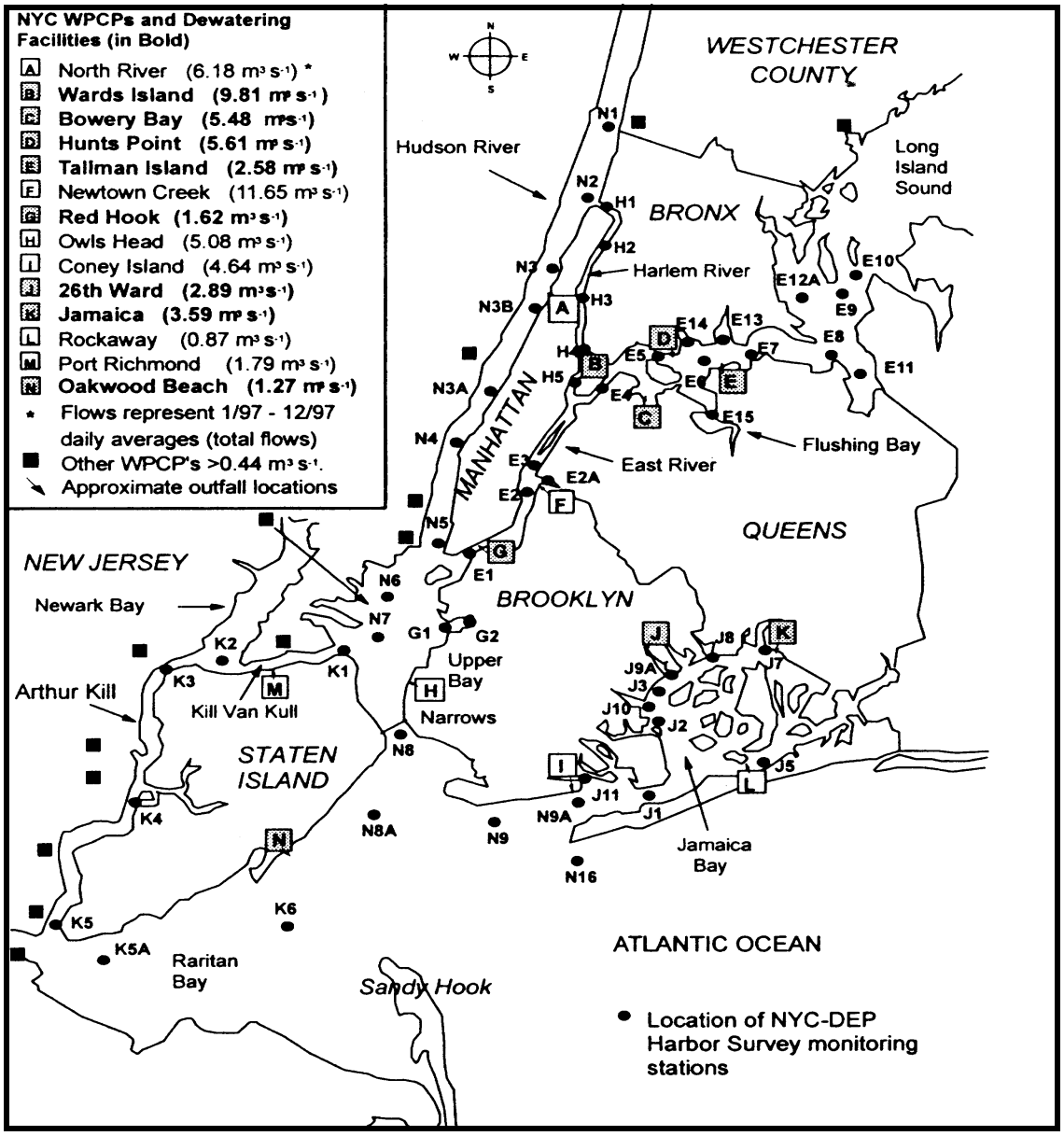


Mean and range of salinity and nutrient concentrations observed in surface waters (depth=1.0m) during the six cruises, versus distance from the Main Street Bridge, Pawtucket, Rhode Island at the head of the Seekonk River.



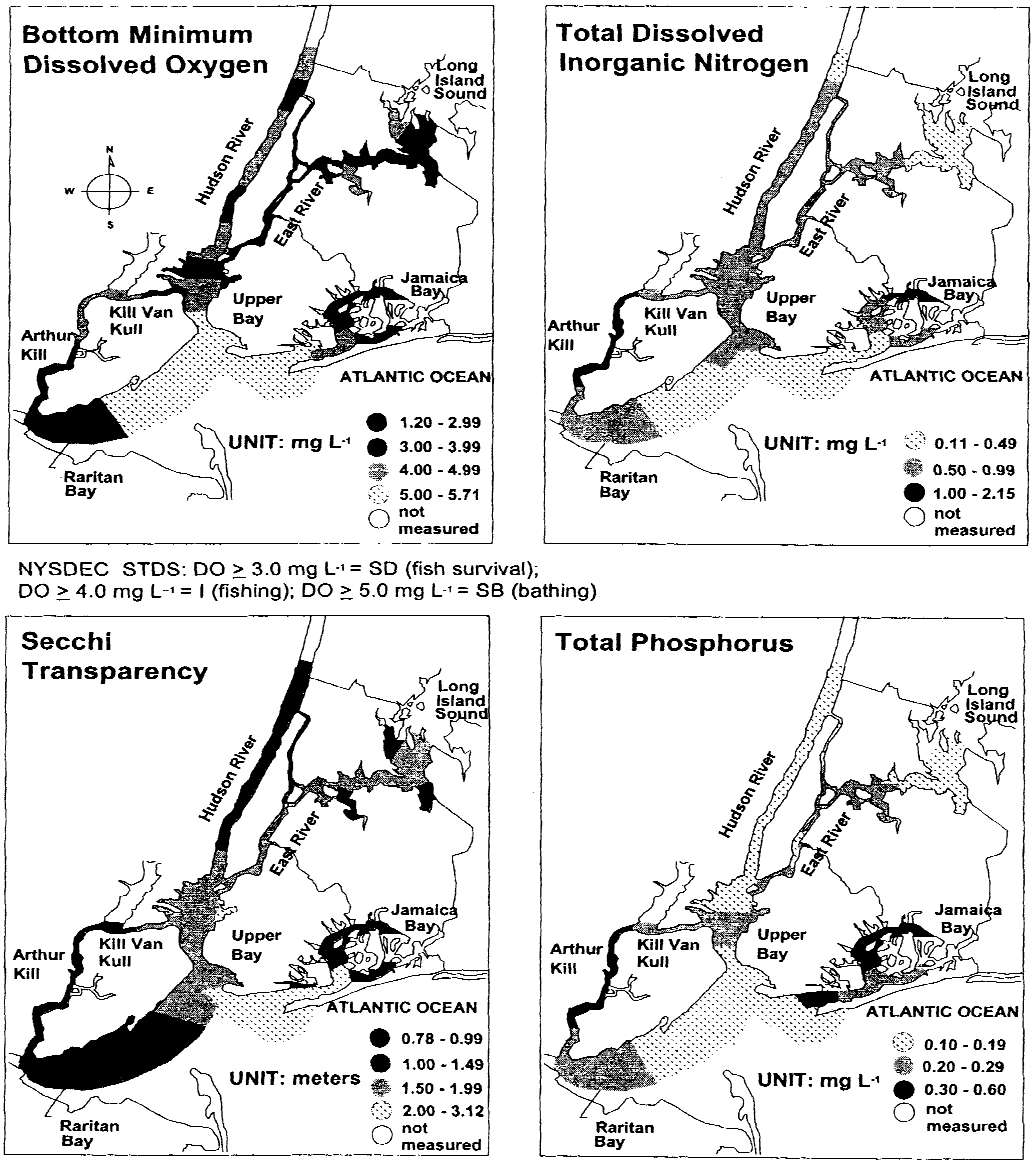
Mean and range of salinity and nutrient concentrations observed in bottom waters (1.0 m from bottom) during the six cruises, versus distance from the Main Street Bridge, Pawtucket, Rhode Island at the head of the Seekonk River.

LOCATION OF WPCP's AND SAMPLING STATIONS IN NY HARBOR



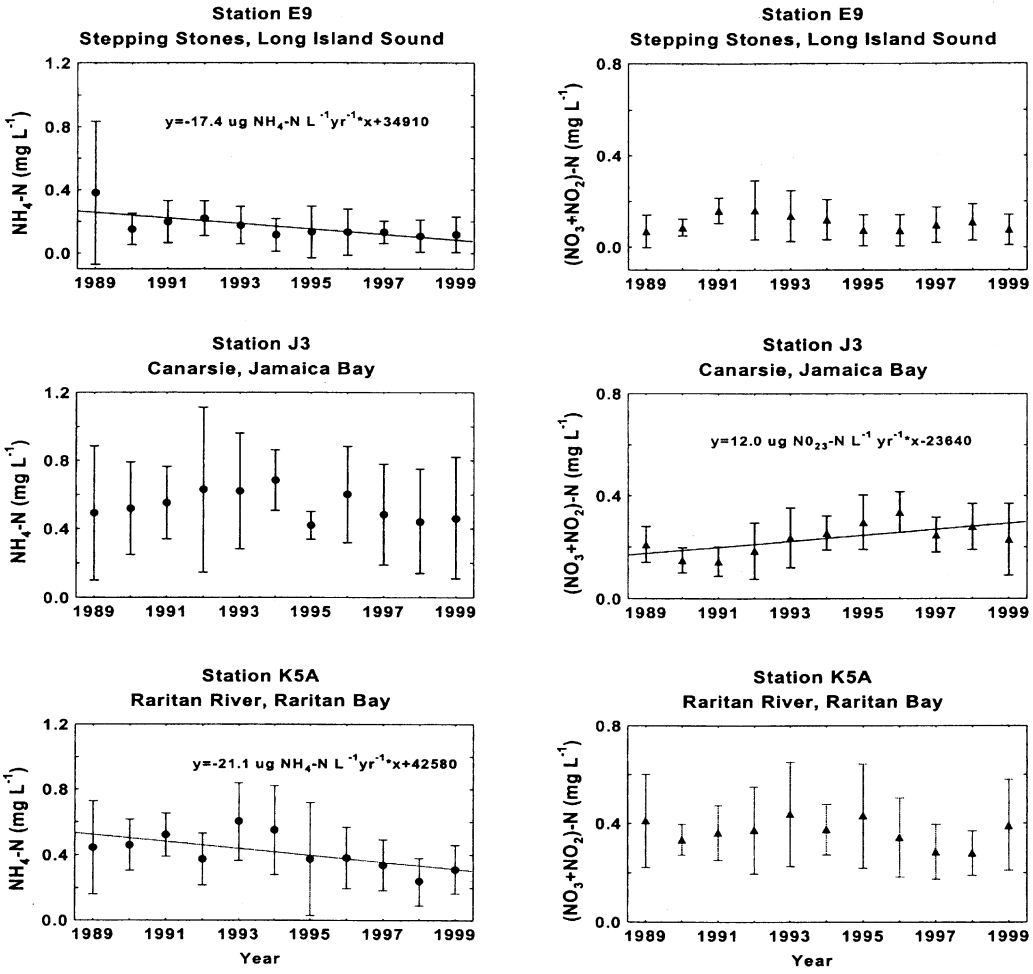
Location of New York City Department of Environment Protection's Harbor Survey Water Quality Monitoring Stations. Also depicted are the 14 New York City Water Pollution Control Plants and the 8 New York City sludge dewatering facilities (shaded boxes). Sandy Hook, lower center, is located at approximately 40°30'N, 74°W.

WATER QUALITY INDICATORS FOR SUMMER 1999



Key water quality indicators for summer (June–September) of 1999. Depicted are: bottom minimum dissolved oxygen (upper left) in mg l^{-1}; summer average dissolved inorganic nitrogen [NH_3–N+(NO_3+NO_2)–N] (upper right) in mg l^{-1}; summer average Secchi transparency (lower left) in m; summer average total phosphorus (lower right) in mg l^{-1}.

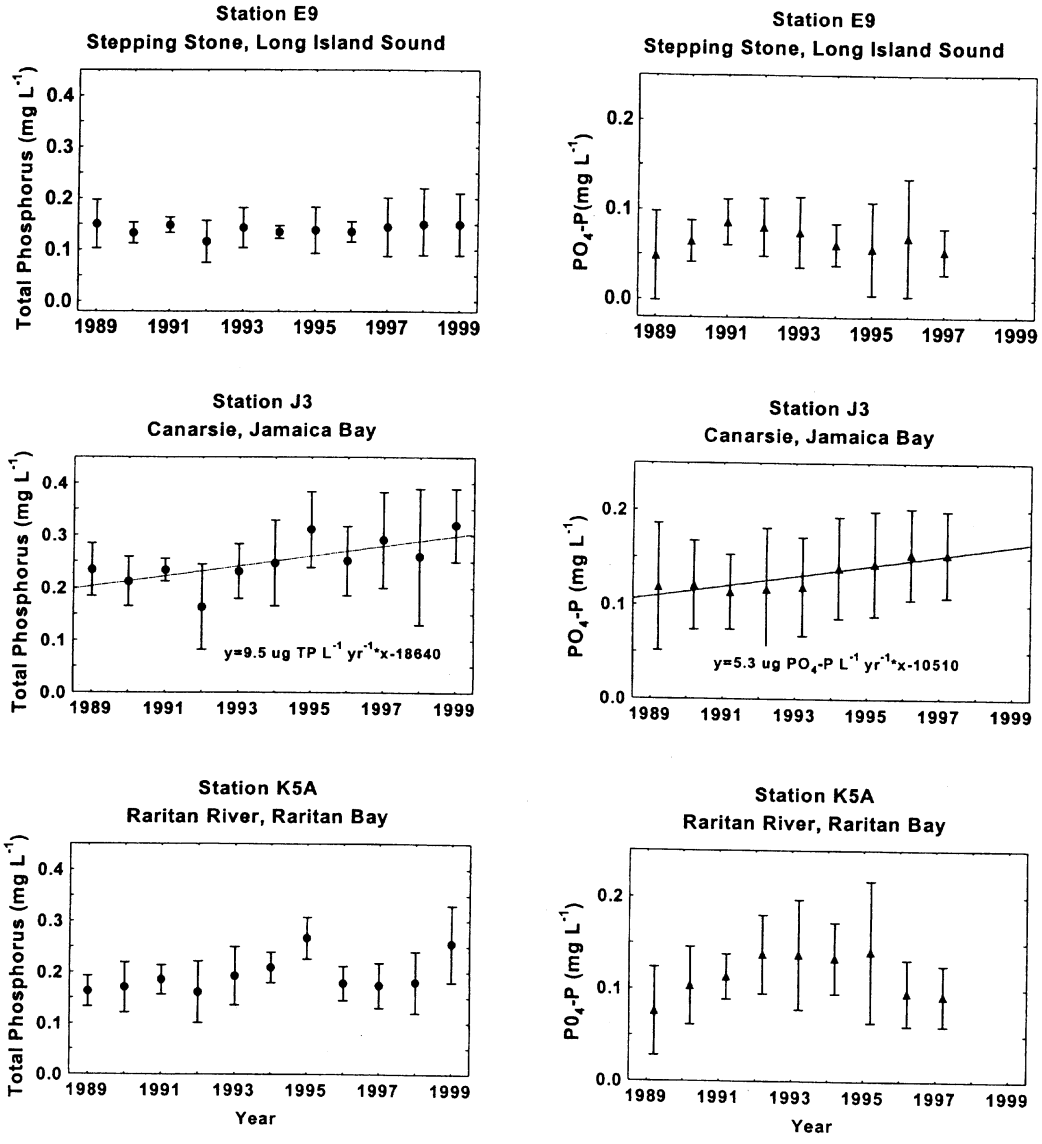
Dissolved Inorganic Nitrogen Trends
Summer Means, 1989-1999



Whisker=Mean±SD

1989–1999 summertime (June–September) average ambient dissolved inorganic nitrogen [dissolved ammonium-nitrogen (NH_4-N) and dissolved nitrate- and nitrite-nitrogen (NO_3)-N] concentrations (mg l^{-1} for western Long Island Sound, Raritan Bay, and Jamaica Bay stations. Trends in summertime average concentrations are noted where significant ($p < 0.05$).

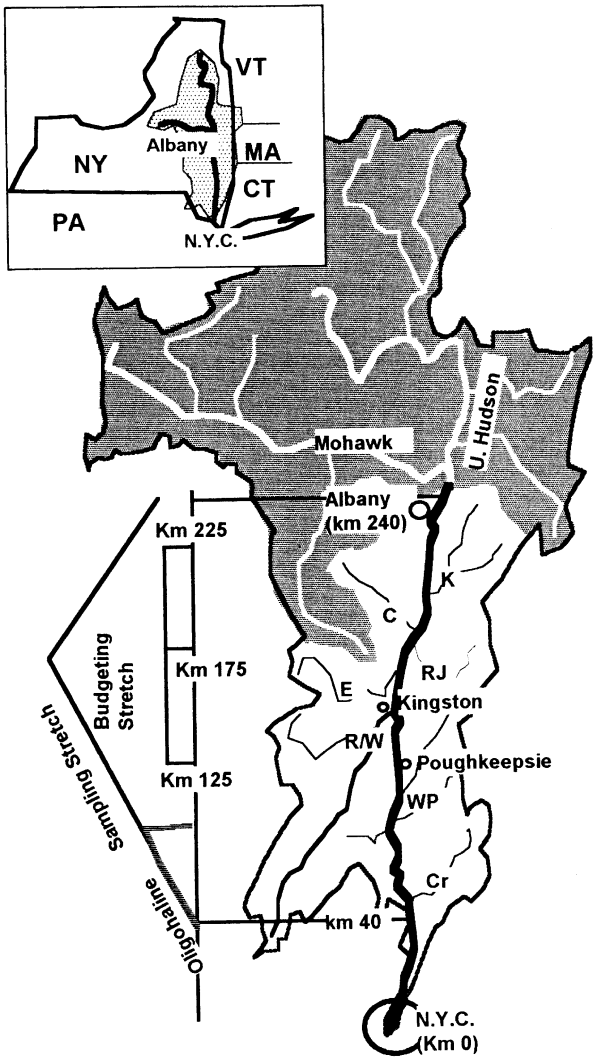
Phosphorus Trends
Summer Means, 1989-1999



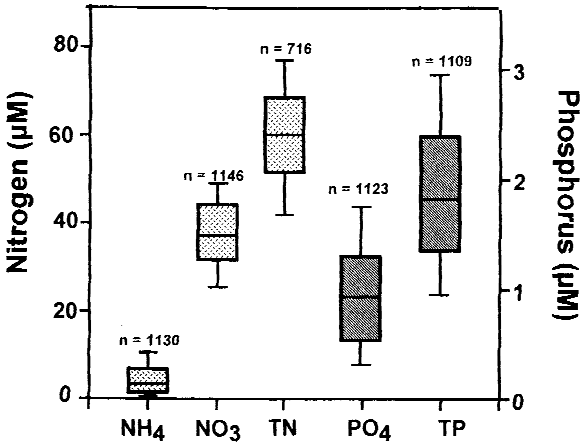
Whisker=Mean±SD

1989–1999 summertime (June–September) average ambient total phosphorus (TP) and dissolved orthophoshpate (PO_4-P) concentrations (mg l^{-1}) for western Long Island Sound, Raritan Bay, and Jamaica Bay stations. Trends in summertime average concentrations are noted where significant ($p < 0.05$).

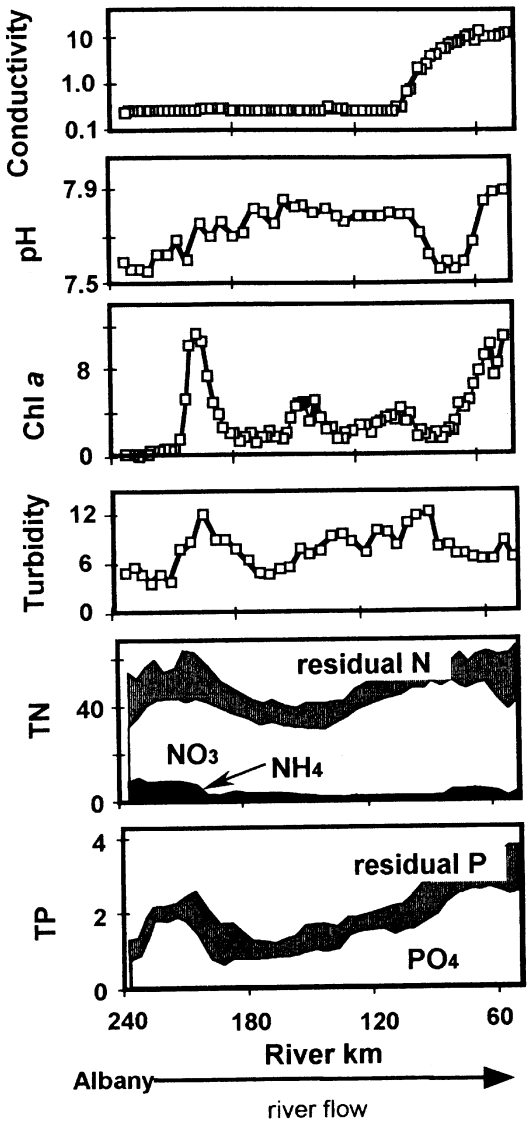
Hudson River, NY



Map of the tidal freshwater Hudson River, its watershed and major tributaries. The inset shows the location of the watershed of the watershed of the Hudson, primarily in eastern New York State. The main panel shows the watershed of the Hudson. The upper (non-tidal) tributaries are in white and their surrounding watershed is shaded. The remaining, unshaded, section of the watershed delivers water to the tidal Hudson River (heavy black line) primarily through 7 tributaries. These tributaries (creeks) are labeled: K for Kinderhook; Cfor Catskill; RJ for Roeloff Janson Kill; E for Esopis; R/W for Rondout/Wallkill; WP for Wappingers; Cr for Croton. The first 5 of these tributaries enter within the budgeting reach (labeled) between km 225 and 125. The section of the river that was sampled during our transect sampling (labeled sampling stretch) is also shown.

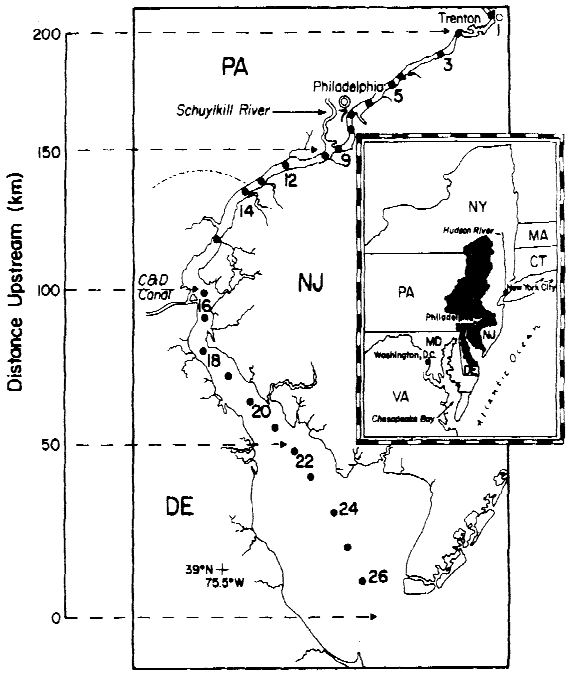


Box and whisker plots for forms of N and P for the entire data set of the Hudson. The data include all samples taken from January 1992 to December 1996 and combine seasonal and spatial variation. Shown are the medians, upper and lower quartiles and 90% inclusion lines. The number of samples for each analysis is labeled near the boxes.



Spatial variation in selected variables for a representative transect taken in early September 1996. Transects run km 240 (Albany downstream to km 40. For each variable samples were taken every 2 to 4 km. Units are, conductivity—(note log scale); pH—normal pH units; chlorophyll *a*— 1^{-1}; turbidity— NTU; N and P—µM. For both N and P the per line represents total N and toal P. "Other N" is TN minus DIN (NH_4 plus NO_3); For P, "Other P" is TP minus phosphate.

Delaware River Estuary

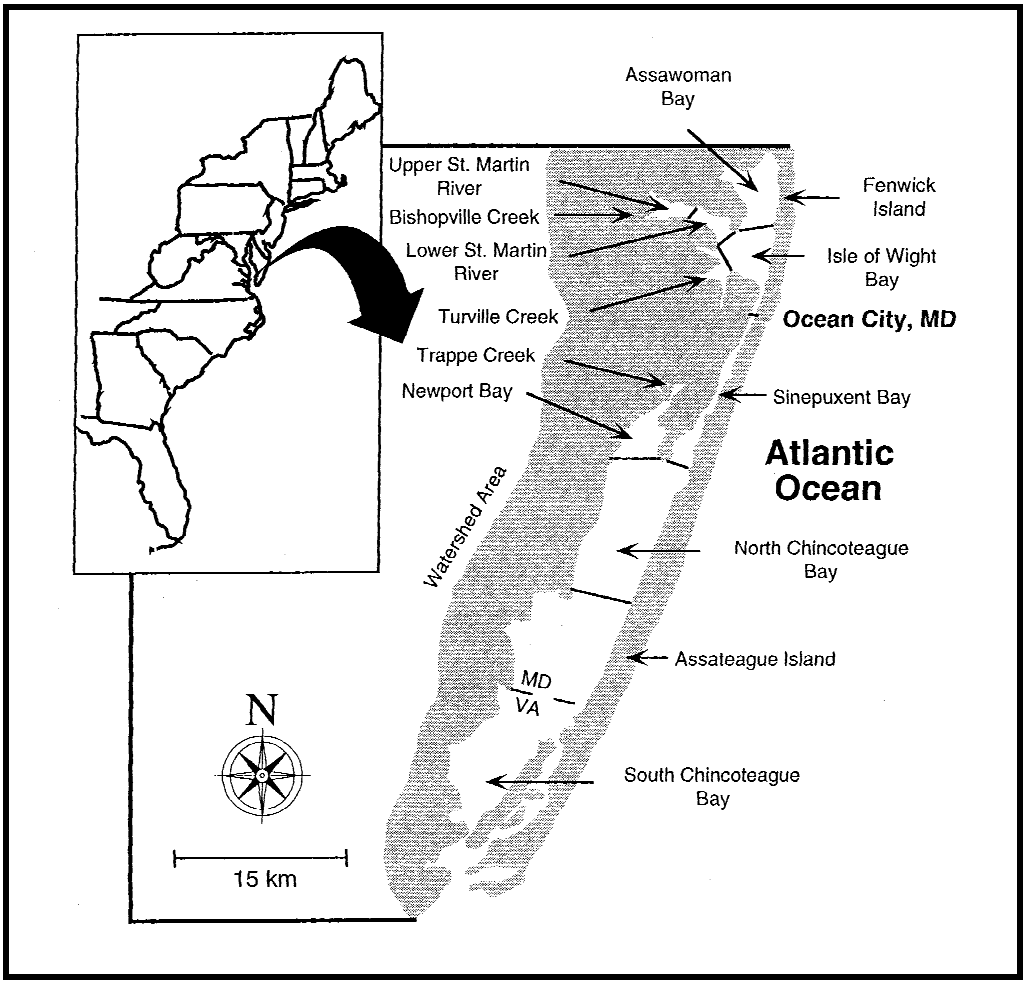


The Delaware Estuary with insert showing relation to the mid-Atlantic coast of the United States. Stations (1-9, 11-26) were located along the main axis of the estuary, every 5-15 km. Station 10 was located in the Schuylkill River (not shown). The river is tidal from the mouth of the bay up to the fall line at Trenton, New Jersey (240 km). Salinity increases from 0.1% at station 14 (130 km) to 30% at the bay mouth. The majority of TP inputs to the river are clustered between stations 6-9.

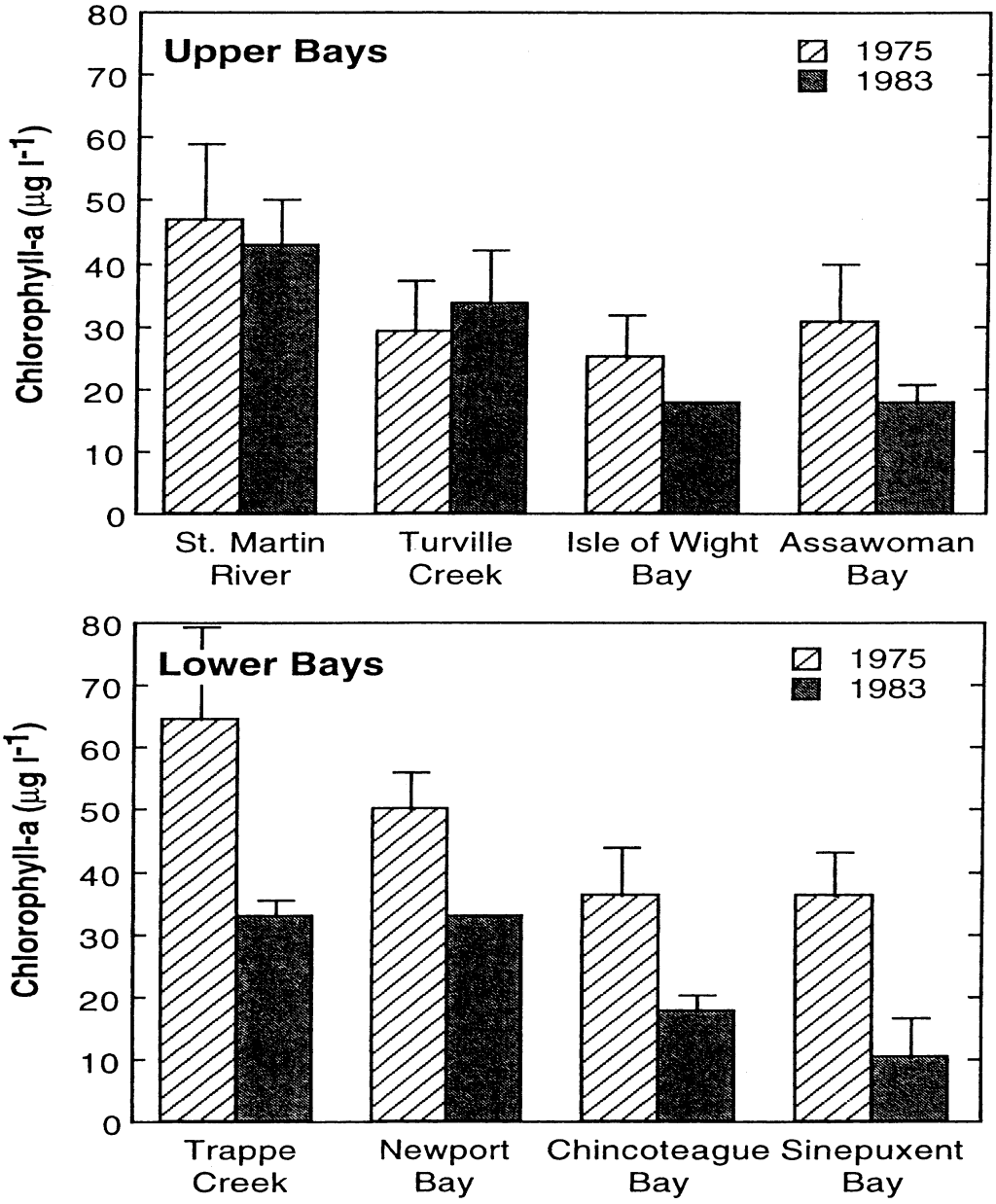
Parameter	Units	2	7	14	16	20	23	RSD
Distance	km	197	161	127	101	66	39	—
Salinity	ppt	<0.1	<0.1	0.1	1.5	11.2	20.4	—
pH	NBS Scale	7.1	6.8	6.9	7.1	7.7	8.0	4
Dissolved oxygen	Percent of saturation	87	73	76	82	96	105	16
Nitrate	μM	74	88	121	122	72	29	35
Total nitrogen	μM	98	126	163	169	94	41	27
Dissolved organic carbon	μM	253	283	287	285	277	208	25
Particulate carbon	μM	36	39	52	138	69	54	47
Secchi depth	cm	129	124	79	33	64	120	36
Phytoplankton production	mmol C m^{-2} d^{-1}	54	40	23	12	47	102	119

Figure 16 Average biological, chemical, and physical parameters for Delaware Estuary 1986-1988. Values are the nonweighted mean of 17 to 24 discrete samples taken at each location (Lebo et al. 1990). Data are shown for locations near the Delaware River (station 2), Philadelphia (station 7), beginning of the salinity gradient (station 14), turbidity maximum (station 16), downstream of the turbidity maximum (station 20), and in the lower bay (station 23). In addition, average relative standard deviation (RSD) for all stations is shown. The average standard deviation for station location and salinity was 1.1 km and 2.1%, respectively.

Maryland Coastal Bays

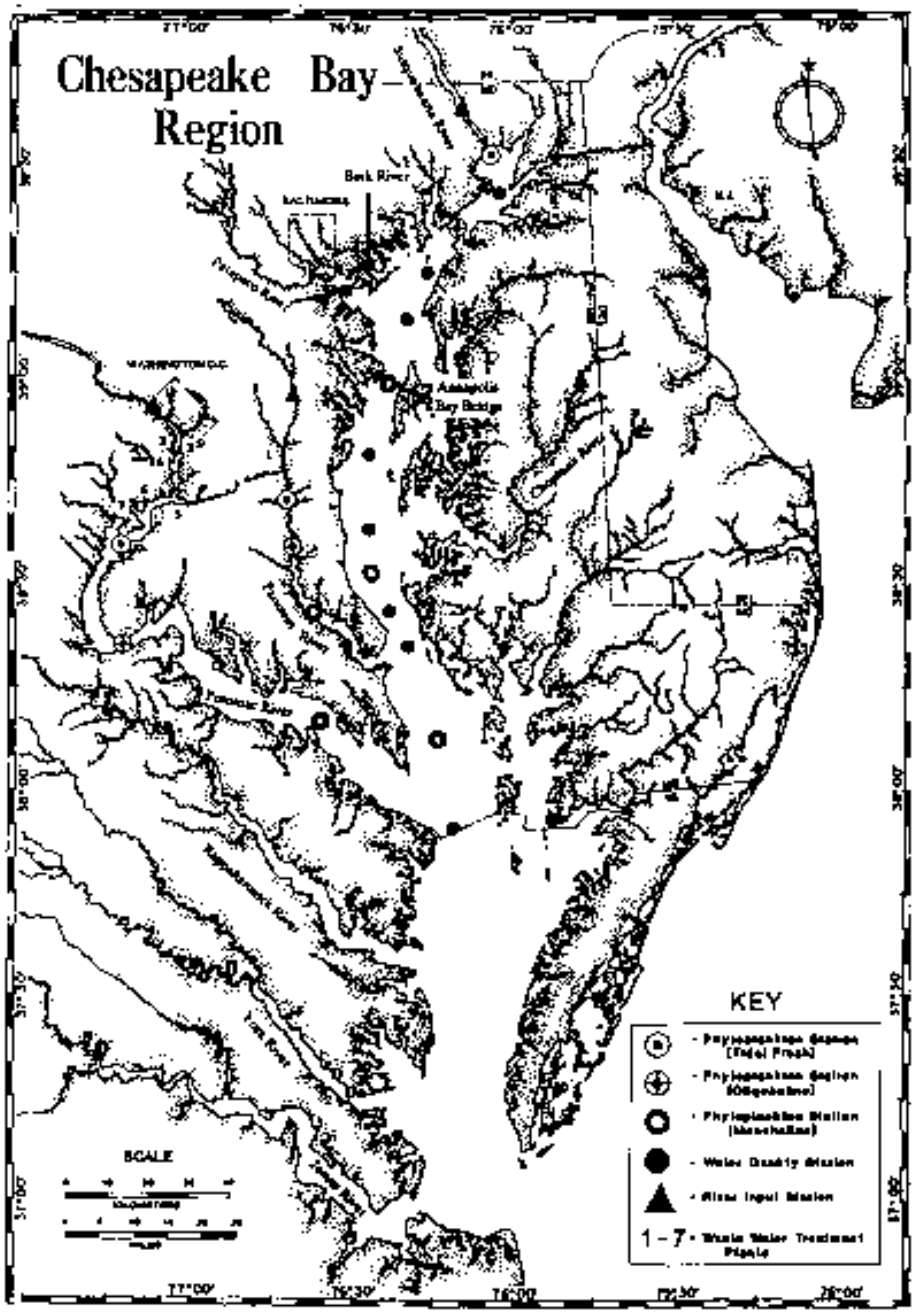


Map of the Maryland coastal bays complex indicating the boundaries of the watershed and a subsystems for which nitrogen inputs were estimated.

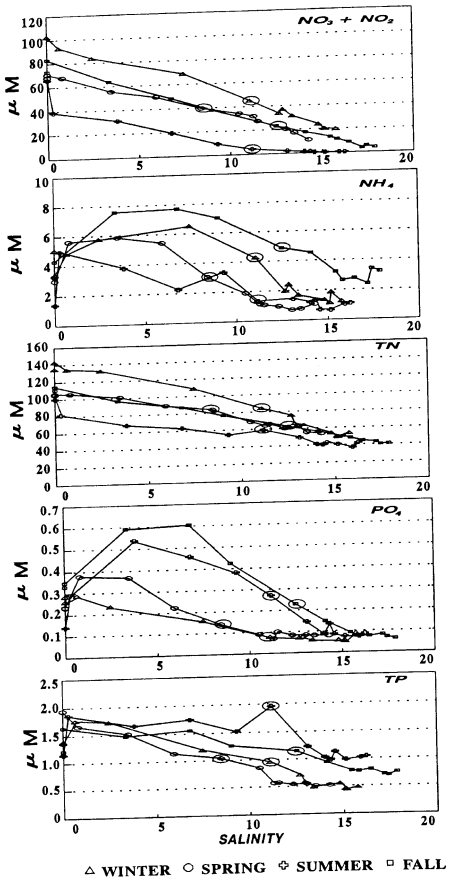


Summer average chlorophyll *a* concentrations for representative regions of the Maryland coastal bays based on samples collected during 1975, 1983, and 1991. Data are from Fang et al. (1977a,b), Maryland Department of Health and Mental Hygiene (1985), and National Park Service (1991).

Chesapeake Bay
Magnien et al.



Map of Chesapeake Bay region showing tributaries, sampling sites, and major wastewater treatment plants for systems examined or referenced in this paper. The major wastewater treatment plants are as follows: 1) Western Branch, 2) Arlington, 3) Blue Plains, 4) Alexandria, 5) Piscataway, 6) Little Hunting Creek, and 7) Lower Potomac.



Salinity dilution plots of nitrate plus nitrite, ammonium, total nitrogen, orthophosphate, and total phosphorus for surface samples at all Chesapeake Bay Mainstream stations. Each point represents a single station at which median values were calculated for each seasonal time frame (see Fig. 2) over the entire 195-1989 period. All stations identified in Fig. 1 were plotted in longitudinal order starting at the head of the estuary. The circled point for each seasonal plot is the upper mesohaline plankton station at the Annapolis Bay Bridge.

Concentrations of ammonium (µM) in Back River, and ammonium concentrations, primary production estimates (mg C m^{-2} d^{-1}) and temperature (°C) for the Patapsco River(Baltimore Harbor). Values presented are surface mixed layer medians by month from continuous monitoring at a frequency of one to two times per month over the period 1985-1989. Station locations are centrally located in each system (see Fig. 1)

	Back River	Patapsco River		
Month	NH_4^+	NH_4^+	Primary Production	Temperature
January	257.0	8.9	299	3.2
February	414.0	48.2	1,384	3.0
March	112.4	24.3	640	6.2
April	439.0	33.6	663	12.3
May	151.7	11.7	1,520	16.8
June	35.7	9.7	1,840	24.3
July	82.1	13.0	2,263	27.2
August	87.5	30.3	1,950	26.6
September	107.1	18.8	1,744	23.8
October	103.5	21.3	953	17.7
November	232.0	15.4	751	11.3
December	317.7	13.1	930	6.5